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Quantum computation schemes based on polar molecules ELENA KUZNETSOVA, ROBIN COTE, University of Connecticut, KATE KIRBY, ITAMP, Harvard-Smithsonian Center for Astrophysics, SUSANNE YELIN, University of Connecticut — Polar molecules have recently attracted significant interest as a viable platform for quantum computing. They combine the advantages of neutral atoms and trapped ions, making them compatible with various architectures, e.g. optical lattices and solid-state systems. Molecules with large permanent dipole moments can display strong dipole-dipole interactions, allowing for the realization of fast conditional two-qubit gates. In recent work we proposed a model of controllable dipole-dipole interactions in which laser excitation from a ground electronic state with negligible dipole moment to an excited metastable electronic state with a large dipole moment allows one to "switch on" the interaction. In principle, two molecules in the excited state interact and acquire a phase shift. We study the robustness of such a phase gate and analyze the experimental feasibility of the approach, using the CO molecule as a specific example. We are continuing to investigate several other schemes involving polar molecules and novel architectures such as a solid-state approach with polar molecules doped into rare-gas matrices.

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